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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF	:
ERIC J STRANG	: EXAMINER: SAXENA, AKASH
SERIAL NO: 10/673,507	:
FILED: SEPTEMBER 30, 2003	: GROUP ART UNIT: 2128
FOR: SYSTEM AND METHOD FOR USING FIRST-PRINCIPLES SIMULATION TO CONTROL A SEMICONDUCTOR MANUFACTURING PROCESS	:

REQUEST FOR REHEARING

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:

This is a Request for Rehearing in response to Board Decision dated March 5, 2010. The Board presented a rejection based on a newly cited portion of Tan et al, apparently without considering the previously filed arguments presented in the Appeal Brief and in the Reply Brief as to the whole of Tan et al, specifically to their teaching of the use of post-process data (not process data relating to an actual process being performed) to ***update and store*** a model for a subsequent processing step.

The Board also failed to address the arguments separately made in the Appeal and Reply Briefs regarding the non-obviousness of selected ones of the dependent claims.

Firstly, Claim 1 defines a method of controlling a process performed by a semiconductor processing tool, including:

> 1) inputting process data relating to an actual process being performed by the semiconductor processing tool,
>
> 2) inputting a first principles physical model including a set of computer-encoded differential equations, the first principles physical model describing at least one of a basic physical or chemical attribute of the semiconductor processing tool,
>
> 3) performing first principles simulation for the actual process being performed ***during performance of the actual process*** using the physical model to provide a first principles simulation result in accordance with the ***process data relating to the actual process being performed*** in order to simulate the actual process being performed, ***said first principles simulation result being produced in a time frame shorter in time than the actual process being performed,*** and
>
> 4) using the first principles simulation result ***obtained during the performance of the actual process*** to control the actual process being performed by the semiconductor processing tool.

The claim defines clearly a process where data input from an actual process being performed is used for producing a first principles simulation result, produced for the actual process being performed during performance of the actual process. The result obtained is produced in a time frame shorter in time than the actual process being performed. The result obtained is then used to control the actual process being performed by the semiconductor processing tool.

The Board's decision now cites Tan et al. for Tan et al's teaching:

1) (as the Examiner cites, from col. 2, lines 7-10) model-based real time process control using in situ inputs, process models, and process control strategies to correctly process control parameters during the process run,

2) (newly cites, from col. 2, lines 61-62) a set of cooperating components to address the above-mentioned problems.

Yet, as noted in Appellant's Reply Brief, the first part of Tan et al cited does not teach 1) performing first principles simulation for the actual process being performed ***during***

performance of the actual process using the physical model to provide a first principles simulation result in accordance with the process data relating to the actual process being performed in order to simulate the actual process being performed, or 2) that the ***first principles simulation result being produced in a time frame shorter in time than the actual process being performed.***

Indeed, the clearest reading of the first part of Tan et al cited above is that it is the "process control" and not the modeling which is real time. Therefore, Tan et al do not perform first principles simulation for the actual process being performed ***during performance of the actual process*** using the physical model to provide a first principles simulation result ***in accordance with the process data relating to the actual process being performed*** in order to simulate the actual process being performed.

Support of Appellant's position on this matter with regard to the deficiencies in Tan et al was discussed in Appellant's Appeal Brief and Reply Brief with regard to the "failure of others." As noted in the Reply Brief, Tan et al teach the use on an ***existing*** process model for feedback or feed forward processing. In feedback control, by definition, the results of a process step are provided to a subsequent wafer. In feed forward control, the results of a prior process step are used to adjust a subsequent process being run of the wafer. Tan et al describe:

> The illustrative APC Framework 200 includes a process model 202 that receives ***feed-forward and feed-back data*** and calculates a processing parameter. The illustrative portion of the APC Framework 200 includes two measurement devices, in particular a pre-process metrology machine 204 and a post-processing metrology machine 206. The pre-process metrology machine 204 performs a measurement on a material prior to processing in a processing machine 208 and sends the measurement, as feed-forward data, to the process model 202. The processing machine 208 sends processed material to the post-processing metrology machine 206 ***to measure post-process data which is sent to the process model 202 as feedback data.***
>
> Referring to FIG. 4, a schematic block diagram shows material flow of a processing step 400 of a semiconductor manufacturing process from a process

> engineer perspective. An APC plan 402 ***retrieves a process model*** from the data store 306, then executes a parameter calculation algorithm 404. The APC plan 402 gives the calculated parameters to a machine 406 and directs the machine 406 to execute the process. The machine 406 issues a signal to the APC plan 402 ***when the process execution is complete***. The APC plan 402 sends the calculated parameters to the data history store 310 of the historical database 312.
>
> Referring to FIG. 5, a schematic block diagram shows material flow of a post-process measurement step 500 of a semiconductor manufacturing process from a process engineer perspective. An APC plan 502 sends a message to a machine 504 instructing the machine 504 to measure a post-processed material. The machine 504 sends measurement data to the APC plan 502. The APC plan 502 retrieves an old process model from the data store 306. The APC plan 502 executes a model update algorithm 506. The APC plan 502 ***stores an updated model in the data store 306 for usage in the processing step 400***. The APC plan 502 sends new model data to the data history store 310 of the historical database 312. [Emphasis added.]

Thus, Tan et al use post-process data to ***update and store*** a model for a subsequent processing step. It is the updated model (based on data measured from a prior run) that is used to control the next process run, thereby providing model-based real time process control during the process run. Yet, this process control during the process run is based on data from a previous run and based on an updated and stored simulation result.

In other words, the Board will appreciate that, in Tan et al, the model exists from previous runs, and essentially the whole disclosure revolves around the issue of how one can keep these models up-to-date as wafers are processed. Figure 2 of Tan et al (reproduced below) shows explicitly the use of "feed-forward data" and "feed-back data" for process control modifications. Figure 3 of Tan et al shows explicitly the use of "pre-process metrology" in what would be a feed-forward control scheme. Figures 4 and 5 were discussed above for their use of an updated model to control a subsequent process.

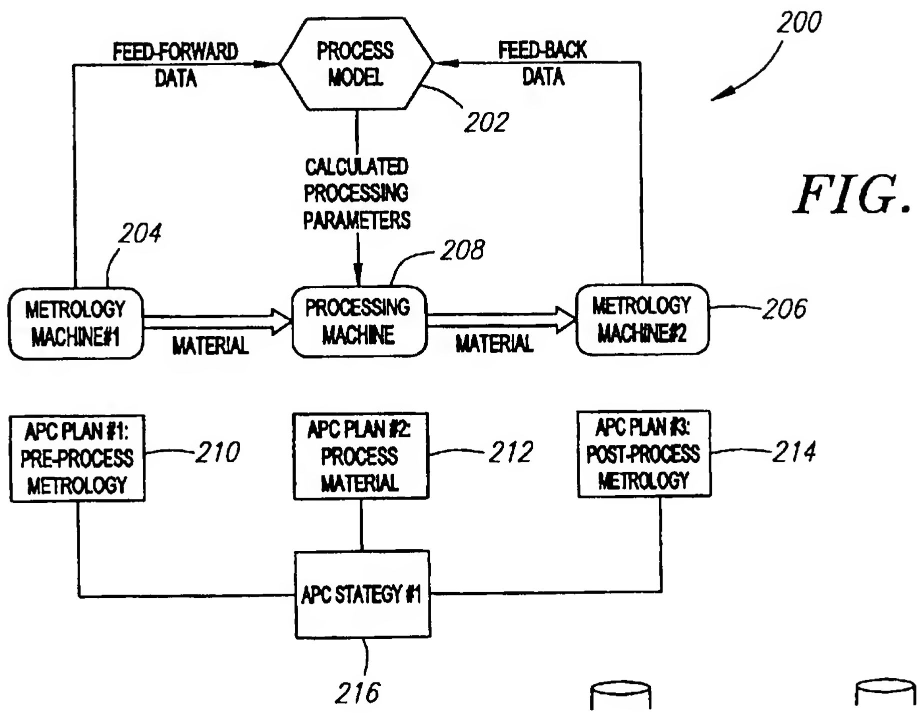

FIG. 2

Figures 6-24 of Tan et al are believed to merely provide implementation details as to the processing described above.

Hence, the Board will appreciate that nowhere does Tan et al disclose or suggest process models and process control strategies created or changed during the process. Rather, in Tan et al, the updated and stored process model (based on the feed-forward data and feed-back data) is applied as it stood at the moment when the wafer process starts, and process control is based on that pre-existing model obtained on the basis of data from other process runs.

Thus, Tan et al do not disclose or suggest performing first principles simulation for the actual process being performed ***during performance of the actual process*** using the physical model to provide a first principles simulation result ***in accordance with the process***

data relating to the actual process being performed in order to simulate the actual process being performed.

Hence, the 35 U.S.C. § 103(a) rejection of 1-21, 29-30, 32-34, 37-58, 66-67, 69-71, 74, and 78 as being unpatentable over Sonderman et al in view of Jain et al and Tan et al should be reversed.

Secondly, the Board failed to address the other arguments separately set forth with regards to **1)** the rejection of Claims 22 and 59, **2)** the rejection of Claims 23-28 and 60-65, **3)** the rejection of Claims 31 and 68, **4)** the rejection of Claims 35 and 72, and **5)** the rejection of Claims 79 and 80. Indeed, the relevant part from the Table of Contents of Appellant's Appeal Brief is reproduced below.

Those arguments (in the Appeal Brief and maintained in Appellant's Reply Brief) are set out again below for the Board's reconsideration.

1) Regarding Claims 22 and 59, the Office Action applies Yunemura et al to overcome the deficiencies of Sonderman et al and Jain et al regarding the features of Claims

22 and 59 directed to an ANSYS computer code. The Examiner's Answer on page 17 states:

> It would have been obvious to one (e.g. a designer) of ordinary skill in the art at the time of the invention was made to apply the teachings of Yunemura and Sonderman and Jain to create an equipment model as disclosed by Sondermann. The motivation to combiner would have been that Yunemura teaches heat modeling on a silicon chip affecting thermal conductivity (Yunemra: Pg, 1407 Section 2) based on various thicknesses and Sonderman is solving the same issue for the equipment model that for example model the equipment for depositing the various layers and affects on heat and pressure.

Yet, the claimed ANSYS computer code is utilized to perform the first principles simulation on the actual process being performed, as defined in Claim 1 from which Claim 22 depends. Meanwhile, Yunemura et al describe simulation modeling on a silicon chip. Thus, Yunemura et al is directed to heat generation and dissipation of heat from an operating silicon chip, not the simulation of an actual process being used for the manufacturing of a silicon chip.

Thus, the ANSYS computer codes in Yunemura et al are **not** directed to modeling of a processing condition. Accordingly, a combination of Yunemura et al and Sonderman and Jain would not produce an ANSYS computer code utilized to perform the first principles simulation on the actual process being performed. Thus, the asserted combination fails to meet the elements of dependent Claims 22 and 59. Moreover, given the differences between the modeling of heat dissipation in an actual device chip and a method of controlling a process performed by a semiconductor processing tool, one of ordinary skill in the art would have no rationale to consider or to use Yunemura et al for developing an ANSYS computer code for controlling a process performed by a semiconductor processing tool.

Hence, for this additional reason (besides their dependence from allowable claims), the 35 U.S.C. § 103(a) rejection of Claims 22 and 59 as being unpatentable over Sonderman et al, Jain et al, and Yunemura et al should be reversed.

2) Regarding Claims 23-28 and 60-65, the Office Action applies Chen to overcome the deficiencies of Sonderman et al and Jain et al regarding the features of Claims 23-28 and 60-65 of choosing a close fitting solution of the first principle simulation to thereby set initial conditions for cell in the first principle simulation. Yet, of the section cited in the Office Action from Chen (col. 5, line 38 to col. 6, line 25), Appellant has previously pointed out that Chen's use of a fitting function described therein is for fitting simulated and measured data, not a solution of a first principle simulation.

The Examiner in response to this argument specifically noted at page 32 of the Examiner's Answer Chen col. 6, lines 35-46. The full paragraph of Chen containing this citation is reproduced below with the Examiner's underscored emphasis shown:

> Corresponding steps of the simulation process 450 are performed in parallel with steps of the actual in-line process 420. A simulation start step 452 begins the simulation process 450 in response to initializing data from the actual in-line process 420. The wafer start step 422 generates initial data, such as orientation data, that is measured and transferred to the simulation process 450, typically through a manufacturing control system, such as Workstream™, the remote access channel of the manufacturing control system, such as Remote Workstream™, and a network connection to the application server, such as TCP/IP. A simulation start step 452 initializes parameters of the simulation process 450 to arbitrary, used-defined values. Following the simulation start step 452, a simulation step 454 simulates the actual process step performed in single process step 424, first using arbitrary, user-defined parameters and later adapting the parameter values on the basis of actual in-line measurements. Various miscellaneous input parameters such as processing time are designated by the test operator. These input parameters are applied to the single process step 424 and the simulation step 454. Input data may be applied in several formats. However, the input data is converted into a statistical distribution function before actual processing begins. For an array of input data points, data is sorted and the probability of a data value being between any two consecutive data points is assumed to be the same. For data presented in statistical form, such as data with a mean, standard deviation and range limits, the data is modeled in a statistical distribution function as a truncated Gaussian profile for usage as a statistical distribution function. For data presented in a statistical form, such as a mean and range limits, the data is modeled in a statistical distribution function as a truncated Gaussian profile with each specified limit being presumed to deviate from the mean value by

> three standard deviations. If the mean is not centered between the range limits, the function is modeled as an asymmetric profile and is considered the combination of two half-Gaussian profiles that have the same population and different standard deviations. For data presented in a statistical form, such as a mean and standard deviation, the data is modeled in a statistical distribution function as a Gaussian profile. Data presented as a single data point is used only for parameters that are insignificant when no additional information is unavailable. Each actual or simulation result, including intermediate results, is applied to the simulation and process as a statistical distribution function, rather than a single data point. Thus, a statistical distribution function is the elementary data type in the simulation system 200.

Once again, Appellant sees no disclosure in Chen of:

> calculating ***a solution*** to the first principles simulation ***by applying a close-fitting solution*** to thereby set initial conditions for cells in the first principles simulation.

Rather, this section of Chen is directed to the arithmetic manipulation of input data, and is not directed to a "close-fitting solution" to a first principles simulation, as defined in Claims 23-26 and 60-63.

Thus, a combination of Chen with Sonderman et al and Jain et al would not yield these claim features.

Furthermore, there is no disclosure in Chen for the features defined in Claims 27-28 and 64-65 regarding choosing a coarse grid for a solution of the first principles simulation (Claims 27 and 64) and then using the solution for coarse grid in a fine grid simulation (Claims 28 and 65).

Thus, for all these reasons, a combination of Chen with Sonderman et al and Jain et al would not produce the feature in Claims 23-28 and 60-65.

Hence, for this additional reason (besides their dependence from allowable claims), the 35 U.S.C. § 103(a) rejection of Claims 23-28 and 60-65 as being unpatentable over Sonderman et al, Jain et al, and Chen should be reversed.

3) Regarding Claims 31 and 68, the Office Action applied Nikoonahad to overcome the deficiencies of Sonderman et al and Jain et al regarding the features of Claims 31, 36, 68, and 73. Claim 31 defines:

> 31. The method of Claim 30, wherein said using the first principles simulation result to control comprises:
> controlling at least one of a chemical vapor deposition system and a physical vapor deposition system.

Yet, the examiner's position as to why it would have been obvious to combine Nikoonahad to Sonderman et al and Jain et al is merely a statement of the teachings being analogous art and both concerning modeling.

Yet, KSR requires an articulated rationale as to why the claimed features are obvious and indicates that conclusory statements are not sufficient. Indeed, the Guidelines for the Patent and Trademark Office, published in Federal Register Vol. 72, No. 195, entitled: "Examination Guidelines for Determining Obviousness under 35 U.S.C. 103 in View of the Supreme Court Decision in KSR International v. Teleflex Inc," indicate that:

> The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious. The Supreme Court in KSR noted that the analysis supporting a rejection under 35 U.S.C. 103 should be made explicit. The Court quoting In re Kahn 41 stated that " '[R]ejections on obviousness ***cannot be sustained by mere conclusory statements***; instead, there ***must be some articulated reasoning*** with some rational underpinning to support the legal conclusion of obviousness.' "

M.P.E.P. § 2141.03 as revised adopts the Federal Register Guidelines.

The Examiner in the Examiner's Answer noted on page 34 that:

> Under KSR, Nikoonahad is a known work in the field of endeavor which may prompt variations of it for use in ether the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art. In this case, Nikoonahad teaches modeling and simulation (Fig. 10 at least) in conjunction with semiconductor fabrication process.

Yet, Figure 10 of Nikoonahad relates to the mathematical simulation of optical data taken from a sample after a process has been performed, where the simulation is used to determine from the optical data features of the processed sample such as for example the height, critical distance (CD), and taper, as shown in Figure 8 reproduced below:

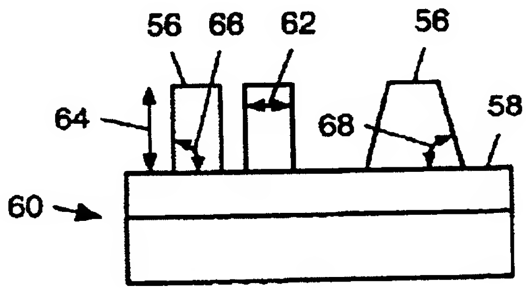

Fig. 8

Furthermore, Figure 13 of Nikoonahad (reproduced below) shows that the optical measurement system 32 is located either besides a lithography tool 130 or interface system 152 with robotic transfers 136 for the transfer of a sample from processing chambers 132, 144, 146, 148, 150, 154, and 156, to the lithography tool 130 or to the interface system 152.

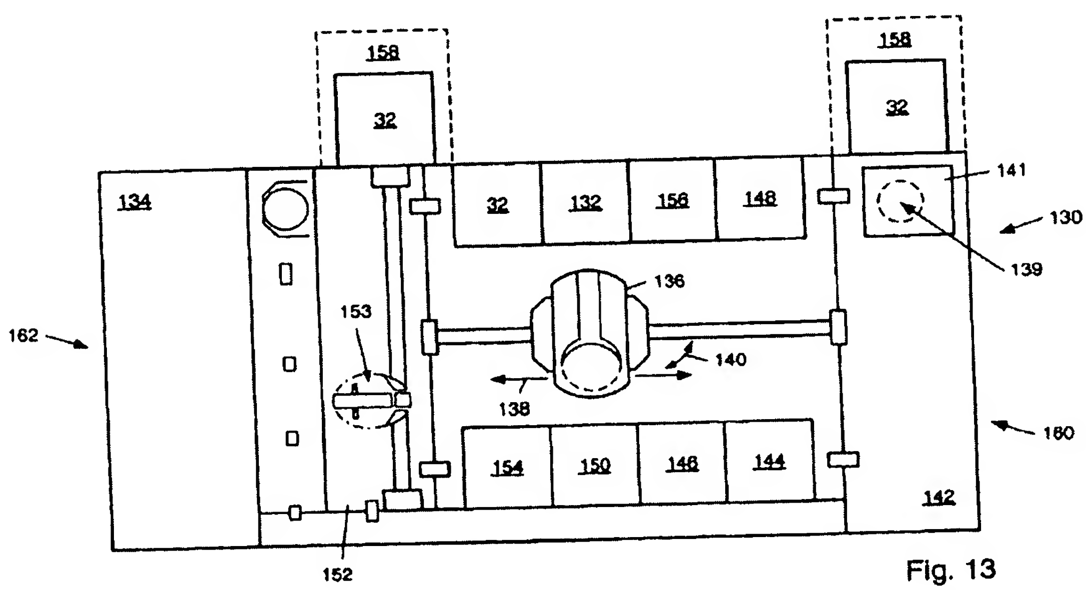

Fig. 13

Thus, the "simulations" in Nikoonahad are post-process simulations used to interpret optical data taken on a processed sample. There is no rationale, suggestion, or motivation that these "simulations" in Nikoonahad have any pertinence or relationship to the claimed using the first principles simulation result to control at least one of a chemical vapor deposition system and a physical vapor deposition system, as defined for example in Claim 31.

Hence, with there still being no articulated reasons given by the Examiner which would support why it would be obvious to arrive at the elements of Claims 31 and 68, based on Nikoonahad, the rejections of Claims 31 and 68 should be reversed.

4) Regarding Claims 35 and 72, the Office Action applied Fatke et al to overcome the deficiencies of Sonderman et al regarding the features of Claims 35 and 72. Claim 35 defines:

> 35. The method of Claim 34, wherein said controlling comprises:
> utilizing at least one of nonlinear optimization and multivariate analysis to derive a control model for process control.

Yet, the examiner's position as to why it would have been obvious to combine Fatke et al with Sonderman et al continues to be merely a statement that the teachings are analogous art and the asserted existence in Fatke et al of one of the claimed elements, which the Office Action asserts can be applied to Sonderman et al.

The Examiner in the Examiner's Answer noted on page 34 that:

> Fatke, as can be clearly seen again, is known work in the field of semiconductor process modeling, which may prompt variations as per KSR and would be obvious to combine it with Sonderman and Jain. Here the variation is the variation in the model of plasma etch process (Fig. 4 & 6).

Once again, the examiner continues to rely only a conclusory statement. Thus, the

rejection of Claims 35 and 72 should be reversed.

5) Regarding Claims 79 and 80, Claim 79 defines that the performing a first principles simulation includes providing for the first principles simulation a reuse of known solutions as initial conditions for the first principles simulation. Claim 80 contains similar claim elements. The Office Action notes that "Jain teaches use of Navier Stokes and other known simulation solutions" and cites pp. 367-368 of Jain et al. However, the Navier Stokes equation on page 367 of Jain et al is a fluid flow equation which needs boundary conditions and which need s to be solved in order to produce a solution. The Navier Stokes equation on page 367 of Jain et al does **not** represent ***a solution***, much less the reuse of known solutions as initial conditions for the first principles simulation, as claimed. Indeed, the examiner should appreciate that the Navier Stokes equation on page 367 is a mathematical statement of ***the problem to be solved***. Appellant's inspection of the remainder of Jain et al finds no disclosure of the reuse of known solutions as initial conditions for the first principles simulation.

The Examiner's Answer on page 31 does not specifically address Appellant's pointed out deficiencies in Jain et al or identify elsewhere in Jain et al that the feature of the reuse of known solutions as initial conditions for the first principles simulation is found. The Examiner's Answer on page 31 merely concludes that the "reuse of the solution would be obvious from Sonderman Col. 7 Lines 8-20."

Sonderman et al states at col. 7, lines 8-20:

> Once the system 100 validates the defined models, the system 100 acquires data to operate the defined models (block 630). In one embodiment, the system 100 acquires data from the computer system 130 in order to operate the defined models. The system 100 then populates the defined models with the data acquired by the system 100 for operation of the models (block 640). In other words, the system 100 sends operation data, control parameter data,

> simulation data, and the like, to the defined models so that the defined models can perform a simulation as if an actual manufacturing process were being performed. The completion of the steps described in FIG. 6 substantially completes the step of preparing process models for simulation, as indicated in block 510 of FIG. 5.

Here, there has been no description in the art of the reuse of known solutions as initial conditions for the first principles simulation, as claimed, and there has been no articulated reasoning given as to why the "reuse of known solutions as initial conditions for the first principles simulation" as claimed is obvious in view of the above-noted description in Sonderman et al.

Hence, for this additional reason (besides their dependence from allowable claims), the 35 U.S.C. § 103(a) rejection of Claims 79 and 80 as being unpatentable over Sonderman et al in view of Jain et al should be reversed.

Conclusion

Appellant request on the basis of the arguments presented above that the outstanding grounds for the rejection be reversed with regard to Tan et al and with regard to the art cited against the dependent claims enumerated above.

Appellant submits that the application is in condition for allowance.

Respectfully submitted,

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